# RESEARCH, EDUCATION AND TRAINING AS PART OF AN ACTION-PLAN TO START UP A RECYCLING POLICY IN JAIPUR, INDIA

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**Abstract**

Being one among the highest population density and a fast growing economy, India doesn't escape from the need for resources. This not only implies the need for energy but also for the raw materials that are by definition ending. A fast growing industry goes hand in hand with an expanding construction sector, which in turn consumes about 40% of all raw materials. Rajasthan is the largest state of India, and is rich metallic and non-metallic mineral resources.It has a flourishing copper and zinc production and it also brings granite, sandstone, and marble of the best quality in the market. These mining operations generate huge amounts of slag and quarry waste. On top of this a huge amount of construction and demolition rubble arises. This growing problem of waste generated in the said processes calls for action; and carefully developing a good recycling policy plan can be a wise decision. To support decision-making by the government research is needed, education is needed to learn the next generations of all people connected to the construction sector and labourers in building companies should be trained to recycle in the proper way. Three universities, KU Leuven, VIT-East and MNITJ have joined forces to tackle this problem..

***Keywords:*** *Recycling, education, research, construction and demolition waste, sustainable material management*

## 1 Introduction

Policies for promotion of cleaner production are a worldwide concern today. The range of recyclable materials and recycling technologies using different types of wastes is widespread. Countries like China are witnessing rapid urbanization, which accounts for about 30-40% of the CDW (Construction Demolition Waste) of the total waste production [1]. India is witnessing increase in infrastructural development and challenges of raw material sustainability. A fast growing industry goes hand in hand with an expanding construction sector, which in turn consumes about 40% of all raw materials. Being one among the highest population density and a fast growing economy, India doesn't escape from the need for resources. This not only implies the need for energy but also for the raw materials that are by definition ending.

Rajasthan, the largest state in India, nearly equals the 64th largest country in the world. It occupies 11% of the total geographical area and 5.66 percent of the population (2011) of India [2]. Rajasthan has mining operations for metallic and nonmetallic minerals such as copper, lead, zinc, wollastonite, marble, sand stone, granite, etc. This in turn, generates huge amounts of wastes in the form of quarry waste and slag of copper, lead and zinc. Wastes marble powder and zinc slag (ISF slag) have already been identified as major environmental threats in the region. Research on various wastes generated in the region is underway at Malaviya National Institute of Technology Jaipur (MNITJ), India. Studies on utilization of ISF slag as fine aggregate in concrete have shown promising results. Studies [3, 4] have reported a feasibility of up to 70% replacement of sand with ISF slag. The durability and dimensional stability of concrete containing 70% ISF slag was at par with the control specimen. Although, it is necessary to establish the feasibility of utilizing industrial wastes as raw materials in concrete, to promote recycling of CDW is imperative. This paper highlights the need of policy framework and education for promoting use of CDW. The entire process of collection, disposal and recycling not being documented in any great detail and many of the figures cited hereby are estimates based on available data from secondary sources like municipal records, research studies conducted for academic purposes, and by reconnaissance study.

## 2 Scenario of CDW in India

Industrialization and rapid urbanization in the past two decades has helped India in experiencing a steady economic growth and become a potential economic world leader. This increased growth has resulted in rising consumerism, especially, in the urban sector. It is estimated that 40% of Indians would live in urban areas by 2021. This would result in rapid diminution of natural resources and pose a threat to sustain country’s ecological development [5]. Furthermore, with rise in consumption levels; the Municipalities across India will face challenge of handling greater amounts and types of waste each year. The World Bank estimates that worldwide municipal solid waste generation was 1.3 billion metric tons in 2012. This is projected to increase to 2.2 billion metric tons per year by 2025. In the 48 million tonnes of solid waste generated in India, CDW in select cities makes up 25% annually [6]. Furthermore, the total quantum of waste from the construction is estimated to be between 12 million to 14.7 million tonnes per annum out of which 7.28 million tonnes are concrete and brick waste. This truly adds gravity to the hazard of municipal waste.

Managing solid waste is one of the most costly urban services in developing countries. Typically, at macro scale it absorbs up to1 per cent of the Gross National Product and at micro level it consumes 20–40% of municipal revenues. Waste generation rate in Indian cities ranges between 200–600 grams/capita/day, depending upon the lifestyle and the size of the city. The urban population in India is growing at 2.7–3.5% per annum; the per capita waste generation is increasing annually by about 1.3%, which indicates an annual increase of solid wastes in the cities of more than 5 per cent [7]. Jaipur is one of the top cities in terms of per capita waste generation in India, giving it sufficient merit for being a choice for this study.

Municipalities across India are facing up to a gargantuan task, as they undertake management of increase in municipal waste generated in the region. It is increasingly being propagated that many of these components can be privatised with immediate economic and other advantages to the municipalities. It is imperative to harness the strength in waste handling. Hence, the idea of privatisation of waste collection and reprocessing is now becoming accepted more widely, and in some cases, even implemented [5]. In the urban territory of Jaipur, also known as the Metropolitan Area of Jaipur (JMA), providing basic service to handle the solid waste is primarily the responsibility of the three local bodies- the Municipal Corporation of Jaipur (JMC), the Municipality of Bagru and Chomu, the two census towns located at significant distance from the core urban area, the Cantonment Board (CB) and the Village Panchayats (VP) mosaic of urban villages. Among these, JMC is the largest local body with the responsibility of providing the basic amenities to both rural and urban areas encompassing nearly 239 sq. km. of metropolitan area of Jaipur. The domain of JMC has been selected for estimating the quantities of CDW given some inadvertent limitations of time and availability of secondary data.

Fig. 1 shows the study area of Jaipur City, including the boundaries that are under Jaipur Municipal Corporation (JMC) and Jaipur Development Authority (JDA). In the municipal domain of Jaipur the total municipal solid waste generated has increased by 41% since 2001 to 2014, the average annual increase being 3.15%. JMC continues with traditional practices for collection of its municipal waste, including CDW, using neighbourhood bins. These bins are transported to collection points from where the waste is carried along with rejects (above 90% of the input) and construction and demolition debris for dumping in nearby landfill sites. The JMC spends nearly 34% of its total expenditure toward handling and managing of municipal solid waste, which also is the largest share of expenditure of all categories included in Annual Operations and Maintenance Expenditure done by JMC. This sum is likely to increase sharply in the coming years. Furthermore, such a system having none or piecemeal provisions for reduction or recycling of waste, the existing land fill sites get filled rapidly thus forcing new sites to be identified for use.

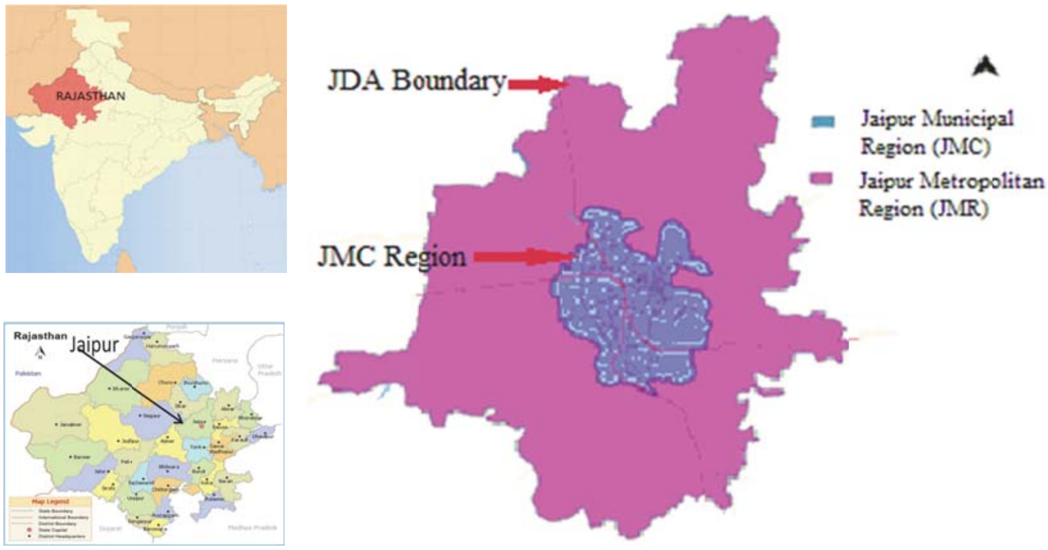


*Fig. 1* *Location of Municipal Region (JMC ) in Metropolitan Area (JMR) of Jaipur*

Currently, over 50% of the waste generated in India is organic, which can be composted and handled separately. The stones and rubble chiefly attributed to CDW consists of 8% of the municipal waste. The proposed integrated management plan for municipal solid waste in Delhi includes minimising waste generation and maximizing reuse and recycling as key interlinked steps [8]. The key to tackle increasing mess in domain of JMC or other Municipal or Panchati- Raj institutions perhaps lies in segregation and recycling the waste. Segregation and recycling of construction and demolition wastes needs to be enhanced to improve level of efficiencies at the processing level and for effective management of municipal waste [9]. This would minimize the quantity of wasteland fills and also save transportation costs. A normative shift would help in establishing a sustainable waste handling system.

## 3 From bottlenecks to solutions

India lacks a formal policy or mandate for reuse of CDW. Belgium has been able to recycle up to 95 % of CDW. In this light, the examples set by European countries, especially, Belgium, can become the torch bearer. The experiences of Belgium would thus, be useful in promoting recycling initiatives in India. Three universities, KU Leuven (Belgium), VIT-East, Jaipur (India) and MNITJ have initiated research and education required for framing recycling policies. This paper is aimed to present the experiences of Belgium that are important for building knowledge base and assurance for practical use of recycled CDW. By Processing CDW we can produce brick/concrete blocks, pavement blocks, kerb-stones, aggregate, etc. for use in buildings, roads and at many more construction activities. Dirt / loose soil to be used for land filling. The focus though is on maximizing recovery of recyclable material(s) from CDW and their reuse in construction activity, this shall also increase the life of sanitary landfill and lower the cost of disposal by relatively significant reduction in the quantity of CDW that cannot be recovered and necessarily have to be disposed in sanitary landfill site(s).

## 4 Examples from Belgium

The European waste policy aims at a recycling CDW to a level of 70% [10]. Recycling CDW has been introduced in the construction sector in Belgium, especially in Flanders, since the 1990s. This was made possible, thankfully, due to the introduction of quality systems, environmental regulations and prescribed use of recycled aggregates in type specifications for public works. The Flanders Public Waste Agency “OVAM” intends to continue this effort and strives towards a sustainable material management for waste materials, closing the loop as much as possible through recycling materials in as high as possible applications [11]. The ValReCon20 research project [12] confirmed that there is potential for the use of coarse RCA of high quality in more advanced applications such as structural concrete. The use of recycled (concrete) aggregates as sub base material in road constructions is considered more as ‘down-cycling’ because a part of the technical and economic potential of the 'good' recycled aggregates is not used. In addition, the question arises whether there is enough room left in the market to continue the supply of recycled aggregates to road constructions or what to do if there is no more market in road constructions because of saturation. At this moment additional or alternative markets become interesting.

In this context, the use of quality recycled concrete aggregates in structural concrete remains on the agenda. Already in 2008, a number of bottlenecks on use of recycled aggregates in concrete were listed [13]. Lack of confidence in the quality of the recycled aggregates, due to variable properties and uncertain origin of the material is the major bottleneck. These aggregates have attached mortar, which results in the low mechanical strength. In addition, possible presence of physical contaminants including chemical components might also adversely affect concrete. Furthermore, there are economic considerations: to conquer a limited market segment a lot of investments have to be done, which in the present context are not compensated in a competitive market. If there is no strong demand e.g. by governmental agencies, then the industry will not easily make the step forward.

## 5 Pilot Case Study in India

As a common practice and due to non-availability of space, construction projects are observed to pile up construction waste on the road and elsewhere around. This practice often causes traffic congestion, accidents, and other environmental issues. Framing CDW policies for India is thus a fresh challenge.

The Ministry of Urban Development has recently initiated recycling of CDW for a project entitled "Redevelopment of East Kidwai Nagar" at New Delhi by setting up a Construction and Demolition Waste Recycling Plant [14]. The old buildings having 2444 units have been replaced by newly constructed of 6,000,000 lac sqft. built up residential area and 12,00,000 sqft. commercial area.

Figs. 2-4 present the photographs of actual photographs of the old dwellings, their demolition, recycling plant, and bricks manufactured using CDW. The Recycling Plant of NBCC processes 150 tonnes per day of the CDW which in turn, produces 30,000 bricks/kerb stone. This is used in the construction of the project which involves demolition of 2444 units and construction of 6,000,000 lac sqft. built up residential area and 12,00,000 sqft. commercial area. With a mandate of ZERO Waste the plant provided cent percent saving in transportation cost of CDW material, mitigating health hazard by reduction in suspended particulate matter in the environment, help maximizing reuse of recoverable materials in construction activity and minimizing waste quantity that requires land fill disposal. This initiative can be adopted as best practice for redevelopment projects in future.

***Fig. 2*** *Old dwelling units and their demolition for redevelopment*

***Fig. 3*** *CDW Recycling Plant*

***Fig. 4*** *Machine for manufacturing CDW Bricks*

## 6 Suitability for use of recycled concrete aggregates

It is necessary to show the suitability of recycled concrete aggregates for use in concrete. This proof can only be given at the level of a clearly identified aggregate, i.e. RCA from a particular supplier and production unit. Only the manufacturer of the recycled material can vouch for the quality control of the production process (incoming and selection, production, control outgoing products) (Fig. 7, Fig. 8) and continuously ensure the quality and conformity of its products that way. The quality assurance for production control and product properties of recycled concrete aggregates for use in concrete should be insured as far as it is not already included in the existing quality control system. The fitness for use for the defined product can be demonstrated in one or more concrete compositions which are representative of the selected application. A possible tool for the certification of this argument is a quality label. The result is an approval that ensures the user that the recycled concrete aggregates continuously comply to the specified requirements (certification), and confirms the conditions for use in a concrete composition, such as maximum strength class and environmental exposure classes, any compositional requirements, necessary precautions, etc.

***Fig. 5*** *Recycling plant*

***Fig. 6*** *Selective stockpiling*

## 7 Key Objectives of the pilot program in Jaipur

A formal policy is essential to promote sustainable practices and use of CDW. A joint effort to establish and promote use of CDW in construction activities is proposed. The project will be a joint initiative by three universities, KU Leuven (Belgium), VIT-East, Jaipur (India) and MNITJ. The project is expected to fulfil following objectives:

i. **Establishing Recycling Plant and Institute:** The first objective would be to set-up a recycling plant for segregation of wastes and to recycle different materials.
ii. **Separation of coarse aggregates:** Coarse aggregates would be separated for its reuse.
iii. **Manufacturing bricks and paving tiles from CDW**: The nature of CDW depends on the type of source construction. After separation of coarse aggregates, the remaining CDW would be used for manufacturing bricks and paving tiles.
iv. **Practical use:** The recycled coarse aggregates, bricks, and tiles would be used in sample projects to observe the performance and practical limitations. As a part of pilot project, various facilities would be built in recycling institute such as theme based public parks, community spaces, exhibition pavilions, etc.
v. **Research:** The prime focus would be to develop research facilities to characterize CDW and test the long term performance in laboratory.

vi. **Education and Training:** The success of use of CDW depends on effective education and training of construction engineers, contractors, and consultants. It is proposed that the recycling institute will design curriculum for training of construction professionals and engineering students. Elective course(s) on recycling and sustainable materials management is proposed to be introduced. Short online modules can also be introduced. People's awareness and sensitivity can also be increased through social media.

vii. **Dissemination:** Dissemination of knowledge is an imperative component for promotion of new techniques and its acceptance. Conferences and Workshops would be organized to disseminate the technology to propagate and adopt these techniques on site.

viii. **Developing Policies:** Developing standards and labeling program for wider application of all such products and construction material for complying with Leadership in Energy and Environmental Design (LEED) or Green Rating for Integrated Habitat Assessment (GRIHA) or Energy Conservation Building Code (ECBC). Improvement in carbon credits at micro and macro level, would be a key objective. Indigenize guidelines, codes and standards; recommend policies and strategies; etc. to mitigate possible environmental or ecological threats on using recycled CDW for new construction.

ix. **Start-ups:** Setting up recycling companies for mass production of construction material by recycling CDW. This can include incentives for traditional or new professionals to adopt manufacturing technology based on recycled CDW.

## 8 Concluding Remarks

Gradual progress can provide definite solutions to the existing obstacles. Research shows that select properties of RCA available in the market lack consistency inspite of coming from one and the same recycling unit. Standards can provide more confidence and a clear goal to be reached, as well as a quality standard that can be pursued by the industry. Sufficient attention should be given to the production of coarse RCA to insure the quality. In any case, the anomalous properties of coarse RCA with respect to the natural aggregates should be taken into account when designing recycling concrete mixtures, in which it is desired to replace fresh aggregates with a high percentage of coarse RCA.

In practice, there is yet an effort to be made. Well documented applications and pilot projects provide a basis for good perception and the basis of practical experience. Therefore it seems sensible to propose a guideline that focus more on the real challenges of making and using recycling concrete. Supported by the policy to reduce and recycle the process can further evolve. More research, standardization, certification and actualization of these best practices using CDW will be of good for a reliable, widely accepted and certified recycled concrete. It is then up to the building sector to also evaluate realize the economic feasibility in practice.

The considerable potential of quality recycled concrete aggregates can be deployed in high performance applications, such as structural concrete, but the current documented empirical data do not allow a general applicability based on normative basis. The collection of empirical data can only be realized if the recycled concrete aggregates are used under controlled conditions on a larger scale. The design of a certification scheme, provides a guarantee of preserving quality to the end user, while providing the possibility for a considerable expansion of the applicability of the recycled concrete aggregates, and within the limits of the certification of recycling concrete.

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